SYSTEM IDENTIFICATION MODEL AND PREDICTIVE FUNCTIONAL CONTROL OF AN ELECTRO-HYDRAULIC ACTUATOR SYSTEM

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Specially dedicated to my beloved family

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ABSTRACT

The nonlinearities, uncertainties, and time varying characteristics of electro-hydraulic actuator (EHA) have made the research challenging for precise and accurate control. In order to design a good and precise controller for the system, a model which can accurately represent the real system has to be obtained first. In this project, system identification (SI) approach was used to obtain the transfer function that can represent the EHA system. Parametric system identification method was utilized in this research as it emphasizes more on mathematical than graphical approach to obtain the model of the system. Multi-sine and continuous step signals were used as the input for the identification process. The models obtained were validated using statistical and graphical approach in simulation and experimental works to decide which model can represent the EHA system more precisely. Predictive functional control (PFC) was proposed and implemented for position control of the EHA. Besides, an optimal proportional-integral-derivative (PID) controller tuned by particle swarm optimization (PSO) was implemented in simulation and experimental work as comparison with the proposed controller. A comprehensive performance evaluation for the position control of the EHA is presented. As expected from the PFC main objective which is to realize closed-loop behaviour close to first order system with time delay, the experimental work conducted shows the controller capability to reduce the overshoot value by 87% as compared to the PID-PSO. The findings also demonstrated that the steady-state error was reduced by 37% and smaller integral absolute error (IAE).

ABSTRAK

Parameter tak lelurus, ketidaktentuan, dan ciri-ciri yang berbeza-beza mengikut masa bagi penggerak elektro-hidraulik (EHA) telah menyebabkan penyelidikan yang mencabar untuk kawalan yang tepat. Dalam usaha untuk merekabentuk pengawal yang baik dan tepat untuk sistem berkenaan, model tepat dan boleh mewakili sistem sebenar perlu diperolehi terlebih dahulu. Dalam projek ini, pendekatan pengenalan sistem (SI) akan digunakan untuk mendapatkan persamaan matematik yang boleh mewakili sistem EHA itu. Kaedah pengenalan sistem parametrik telah digunakan dalam kajian ini kerana ia lebih menekankan kepada matematik daripada pendekatan grafik untuk mendapatkan model sistem. Multi-sinus dan isyarat langkah berterusan telah digunakan sebagai input untuk proses pengenalan. Model-model yang diperolehi disahkan menggunakan pendekatan statistik dan grafik dalam kerja-kerja simulasi dan eksperimen untuk menentukan model yang boleh mewakili sistem EHA yang lebih tepat. Kawalan fungsi ramalan (PFC) telah dicadangkan dan dilaksanakan sebagai kawalan kedudukan EHA. Selain itu, pengawal kadaran-kamiran-terbitan (PID) yang optimum ditala oleh pengoptimuman kawanan zarah (PSO) telah dilaksanakan pada simulasi dan ujikaji sebagai perbandingan dengan pengawal yang dicadangkan. Satu penilaian prestasi yang komprehensif untuk mengawal kedudukan EHA turut dikemukakan. Seperti yang dijangka daripada objektif utama PFC yang menyedari tingkah laku gelung tertutup dekat dengan sistem tertib pertama dengan kelewatan masa, eksperimen yang dijalankan menunjukkan keupayaan pengawal untuk mengurangkan nilai terlajak sebanyak 87% berbanding PID-PSO. Hasil kajian juga menunjukkan bahawa ralat keadaan mantap telah dikurangkan sebanyak 37% dengan pengurangan terhadap kesilapan kecil mutlak (IAE).